

## WHAT IS CLAIMED IS

1. A z-axial solid-state gyroscope, manufactured by a conductive material, two sets of a proof mass and two driver bodies suspended between two parallel plates by an elastic beam assembly so that they can move along a first axis and a second axis parallel to the surface of the plates;  
each surface of each driver body being formed a plurality of grooves perpendicular to the first axis, the surface of each plate corresponding to each driver body being formed two sets of driving electrodes, respectively including a number of stripe electrodes perpendicular to the first axis, the two sets of driving stripe electrodes being interposed each other and being formed two sets of driving capacitors with the corresponding surface of the driver body;  
each surface of each proof mass being formed a plurality of grooves perpendicular to the second axis, the surface of each plate corresponding to the proof mass being formed two sets of sensing electrodes, respectively including a number of stripe electrodes parallel to the grooves of the proof mass, the two sets of sensing stripe electrodes being interposed each other and being formed two sets of sensing capacitors with the corresponding surface of the proof mass; the capacitances thereof changing with the movement of the proof masses along the second axis;  
each driving capacitor being excited with a DC bias and an AC voltage at the mechanical resonant frequency with proper phase thereof;  
the displacement and vibration of each proof mass being able to be obtained by sense the change in the capacitances of the corresponding sensing capacitors thereof;  
the output signals of each proof mass induced by an angular velocity and an acceleration being respectively a AC signal and a DC signal, which can be separated into an angular velocity signal and an acceleration signal by a signal processing technique.
2. The z-axial solid-state gyroscope as claimed in Claim 1, wherein each groove on the surfaces of each proof mass and each driver body are further etched a plurality of deep holes or through holes.

3. The z-axial solid-state gyroscope as claimed in Claim 1, wherein the elastic beam assembly comprises:
  - a number of connection beams, connecting the two driver bodies corresponding to each proof mass;
  - a number of sensing beams, connecting each proof mass to the corresponding two driver bodies thereof and making the proof masses be able to move along the second axis;
  - two common connection beams, positioned at both sides of the proof masses;
  - a number of first elastic beams, connecting the proof masses and the driver bodies to the common connection beams; and
  - a number of second elastic beams, connecting the common connection beams to a central anchor fixed at the two plates.
4. The z-axial solid-state gyroscope as claimed in Claim 1, wherein the elastic beam assembly comprises:
  - a number of sensing beams, connecting each proof mass to the corresponding two driver bodies thereof and making the proof mass be able to move along the second axis;
  - two common connection beams, positioned at both sides of the proof masses;
  - a number of first elastic beams, connecting the proof masses and the driver bodies to the common connection beams; and
  - a number of second elastic beams, connecting the common connection beams to a central anchor fixed at the two plates.
5. The z-axial solid-state gyroscope as claimed in Claim 1, wherein each proof mass is directly connected to the corresponding two driver bodies thereof, and the elastic beam assembly comprises:
  - two common elastic connection beams, positioned at both sides of the proof masses;
  - a number of first elastic beams, connecting the proof masses and the driver bodies to the common elastic connection beams; and
  - a number of second elastic beams, connecting the common elastic connection beams to a central anchor fixed at the two plates.

6. The z-axial solid-state gyroscope as claimed in Claim 3, wherein the elastic beam assembly further comprises a number of third and fourth elastic beams connecting the proof masses and the driver bodies to an outer frame fixed at the two plates.
7. The z-axial solid-state gyroscope as claimed in Claim 4, wherein the elastic beam assembly further comprises a number of third and fourth elastic beams connecting the proof masses and the driver bodies to an outer frame fixed at the two plates.
8. The z-axial solid-state gyroscope as claimed in Claim 5, wherein the elastic beam assembly further comprises a number of third and fourth elastic beams connecting the proof masses and the driver bodies to an outer frame fixed at the two plates.
9. The z-axial solid-state gyroscope as claimed in Claim 1, wherein the elastic beam assembly comprises:
  - two connection beams, connecting the two driver bodies corresponding to each proof mass;
  - a number of sensing beams, connecting each proof mass to the corresponding two driver bodies thereof and making the proof masses be able to move along the second axis; and
  - a number of driving elastic beams, connecting the proof masses and the driver bodies to the outer frame fixed at the two plates.
10. The z-axial solid-state gyroscope as claimed in Claim 1, wherein the driving capacitors of the two driver bodies corresponding to each proof mass are divided into two parts:
  - the first part of the driving capacitors being excited with a DC bias and a AC voltage and making the proof mass move along the first axis; and
  - the second part of the driving capacitors being excited with a DC bias and a high frequency AC voltage to sense the vibration amplitude signal of the proof mass along the first axis and feedback it to the first part of the driving capacitors to control the vibration amplitude of the proof mass along the first axis.

11. The z-axial solid-state gyroscope as claimed in Claim 1, wherein each sensing capacitor are partitioned into two parts:
  - the first part of the sensing capacitors being excited with a DC bias and a high frequency AC voltage to sense the z-axial angular velocity signal and the second axial acceleration signal; and
  - the second part of the sensing capacitors being to obtain the signal of the angular velocity and generate a feedback signal for rebalancing the vibration of the proof masses due to a Coriolis force, along the second axis.
12. The z-axial solid-state gyroscope as claimed in Claim 1, the main configuration thereof being manufactured with a (110) silicon chip by bulk micromachining technique.
13. A solid-state gyroscope, manufactured by a conductive material, two sets of a proof mass and two driver bodies suspended between two parallel plates by an elastic beam assembly so that the proof masses can move along a first axis parallel to the surface of the plates and along a z-axis perpendicular to the surface of the plates;
  - each surface of each driver body being formed a plurality of grooves perpendicular to the first axis, the surface of each plate corresponding to each driver body being formed two sets of driving electrodes, respectively including a number of stripe electrodes perpendicular to the first axis, the two sets of driving stripe electrodes being interposed each other and being formed two sets of driving capacitors with the corresponding surface of the driver body;
  - the surface of each plate corresponding to each proof mass being formed a sensing electrode; the sensing electrodes and the surfaces of each proof mass being formed two sensing capacitors, the capacitances thereof changing with the movement of the proof masses along the z-axis;
  - each driving capacitor being excited with a DC bias and an AC voltage at the mechanical resonant frequency with proper phase thereof;
  - the displacement and vibration of each proof mass being able to be obtained by sense the change in the capacitances of the corresponding sensing capacitors thereof;

the output signals of each proof mass induced by an angular velocity and an acceleration being respectively a AC signal and a DC signal, which can be separated into an angular velocity signal and an acceleration signal by a signal processing technique.

14. The solid-state gyroscope as claimed in Claim 13, wherein the grooves on the surfaces of each proof mass and each driver body are further etched a plurality of deep holes or through holes.
15. The solid-state gyroscope as claimed in Claim 13, wherein the elastic beam assembly comprises:
  - a number of connection beams, connecting the two driver bodies corresponding to each proof mass;
  - a number of sensing beams, connecting each proof mass to the corresponding two driver bodies thereof and making the proof masses be able to move along the z-axis;
  - two common connection beams, positioned at both sides of the proof masses;
  - a number of first elastic beams, connecting the proof masses and the driver bodies to the common connection beams; and
  - a number of second elastic beams, connecting the common connection beams to a central anchor fixed at the two plates.
16. The solid-state gyroscope as claimed in Claim 13, wherein the elastic beam assembly comprises:
  - a number of sensing beams, connecting each proof mass to the corresponding two driver bodies thereof and making the proof mass be able to move along the z-axis;
  - two common connection beams, positioned at both sides of the proof masses;
  - a number of first elastic beams, connecting the proof masses and the driver bodies to the common connection beams; and
  - a number of second elastic beams, connecting the common connection beams to a central anchor fixed at the two plates.

17. The solid-state gyroscope as claimed in Claim 13, wherein each proof mass is directly connected to the corresponding two driver bodies thereof, and the elastic beam assembly comprises:
- two common elastic connection beams, positioned at both sides of the proof masses;
  - a number of first elastic beams, connecting the proof masses and the driver bodies to the common elastic connection beams; and
  - a number of second elastic beams, connecting the common elastic connection beams to a central anchor fixed at the two plates.
18. The solid-state gyroscope as claimed in Claim 15, wherein the elastic beam assembly further comprises a number of third and fourth elastic beams connecting the proof masses and the driver bodies to an outer frame fixed at the two plates.
19. The solid-state gyroscope as claimed in Claim 16, wherein the elastic beam assembly further comprises a number of third and fourth elastic beams connecting the proof masses and the driver bodies to an outer frame fixed at the two plates.
20. The solid-state gyroscope as claimed in Claim 17, wherein the elastic beam assembly further comprises a number of third and fourth elastic beams connecting the proof masses and the driver bodies to an outer frame fixed at the two plates.
21. The solid-state gyroscope as claimed in Claim 13, wherein the elastic beam assembly comprises:
- a number of connection beams, connecting the two driver bodies corresponding to each proof mass;
  - a number of sensing beams, connecting each proof mass to the corresponding two driver bodies thereof and making the proof masses be able to move along the z-axis; and
  - a number of driving elastic beams, connecting the proof masses and the driver bodies to the outer frame fixed at the two plates.

22. The solid-state gyroscope as claimed in Claim 13, wherein the driving capacitors of the two driver bodies corresponding to each proof mass are divided into two parts:  
the first part of the driving capacitors being excited with a DC bias and a AC voltage and making the proof mass move along the first axis; and  
the second part of the driving capacitors being excited with a DC bias and a high frequency AC voltage to sense the vibration amplitude signal of the proof mass along the first axis and feedback it to the first part of the driving capacitors to control the vibration amplitude of the proof mass along the first axis.
23. The solid-state gyroscope as claimed in Claim 13, wherein each sensing capacitor are partitioned into two parts:  
the first part of the sensing capacitors being excited with a DC bias and a high frequency AC voltage to sense the second axial angular velocity signal and the z-axial acceleration signal; and  
the second part of the sensing capacitors being to obtain the signal of the angular velocity and generate a feedback signal for rebalancing the vibration of the proof masses, due to a Coriolis force, along the second axis.
24. The solid-state gyroscope as claimed in Claim 13, the main configuration thereof being manufactured with a (110) silicon chip by bulk micromachining technique.
25. A planar solid-state three-axis inertial measurement unit, manufactured mainly by a conductive material, a number of solid-state inertial sensors installed between two parallel plates;  
a first solid-state gyroscope, the angular velocity sensing axis thereof being parallel to the x-axis of the plate surfaces, the configuration thereof comprising: a first and second sets of a proof mass and two driver bodies, a first elastic beam assembly, a first drivers assembly and a first sensors assembly; the first and second sets of proof mass and driver bodies suspended between the two plates by the first elastic beam assembly so that the first and second sets of proof mass and driver bodies can move along the y-axis parallel to the plate surfaces, and the first and second

proof masses can also move along the z-axis perpendicular to the plate surfaces; the first drivers assembly driving the first and second sets of proof mass and driver bodies to vibrate in the opposite direction along the y-axis; the first sensors assembly being able to sense the vibration in the opposite direction and the displacement in the same direction of the first and second proof masses along the z-axis, that meaning the x-axial angular velocity and the z-axial acceleration;

a second solid-state gyroscope, the angular velocity sensing axis thereof being parallel to the  $y'$ -axis of the plate surfaces, the configuration thereof comprising: a third and fourth sets of a proof mass and two driver bodies, a second elastic beam assembly, a second drivers assembly and a second sensors assembly; the third and fourth sets of proof mass and driver bodies suspended between the two plates by the second elastic beam assembly so that the third and fourth sets of proof mass and driver bodies can move along the  $x'$ -axis parallel to the plate surfaces, and the third and fourth proof masses can also move along the z-axis; the second drivers assembly driving the third and fourth sets of proof mass and driver bodies to vibrate in the opposite direction along the  $x'$ -axis; the second sensors assembly being able to sense the vibration in the opposite direction and the displacement in the same direction of the third and fourth proof masses along the z-axis, that meaning the  $y'$ -axial angular velocity and the z-axial acceleration; the preceding  $x'$ ,  $y'$ , and z axes are orthogonal;

a third solid-state gyroscope, the angular velocity sensing axis thereof, z-axial, being perpendicular to the plate surfaces, the configuration thereof comprising: a fifth and sixth sets of a proof mass and two driver bodies, a third elastic beam assembly, a third drivers assembly and a third sensors assembly; the fifth and sixth sets of proof mass and driver bodies suspended between the two plates by the third elastic beam assembly so that the fifth and sixth sets of proof mass and driver bodies can move along the y-axis parallel to the plate surfaces, and the fifth and sixth proof masses can also move along the  $x'$ -axis; the third drivers assembly driving the fifth and sixth sets of proof mass and driver bodies to vibrate in the opposite direction along the y-axis; the third sensors assembly being able to sense the vibration in the opposite direction and the displacement in the same

direction of the fifth and sixth proof masses along the  $x'$ -axis, that meaning the z-axial angular velocity and the  $x'$ -axial acceleration;

one of a fourth solid-state gyroscope and a y-axial solid-state accelerometer;

the fourth solid-state gyroscope, which the angular velocity sensing axis thereof, z-axial, is perpendicular to the plate surfaces, the configuration thereof comprising: a seventh and eighth sets of a proof mass and two driver bodies, a fourth elastic beam assembly, a fourth drivers assembly and a fourth sensors assembly; the seventh and eighth sets of proof mass and driver bodies respectively suspended between the two plates by the fourth elastic beam assembly so that the seventh and eighth sets of proof mass and driver bodies can move along the  $x'$ -axis parallel to the plate surfaces, and the seventh and eighth proof masses can also move along the y-axis; the fourth drivers assembly driving the seventh and eighth sets of proof mass and driver bodies to vibrate in the opposite direction along the  $x'$ -axis; the fourth sensors assembly being able to sense the vibration in the opposite direction and the displacement in the same direction of the seventh and eighth proof masses along the y-axis, that meaning the z-axial angular velocity and the y-axial acceleration;

the configuration of the y-axial solid-state accelerometer comprising: a ninth proof mass, a fifth elastic beam assembly, and a fifth sensors assembly; the ninth proof mass suspended between the two plates by the fifth elastic beam assembly so that the ninth proof mass can move along the y-axis; the fifth sensors assembly being able to sense the y-axial acceleration signal.

26. The planar solid-state three-axis inertial measurement unit as claimed in Claim 25, wherein the elastic beam assembly of each gyroscope comprises:

A number of connection beams, connecting the two driver bodies corresponding to each proof mass;

a number of sensing beams, connecting each proof mass to the corresponding two driver bodies thereof;

two common connection beams, positioned at both sides of the proof masses;

a number of first elastic beams, connecting the proof masses and the driver bodies to the common connection beams; and

a number of second elastic beams, connecting the common connection beams to a central anchor fixed at the two plates.

27. The planar solid-state three-axis inertial measurement unit as claimed in Claim 25, wherein each proof mass is directly connected to the corresponding two driver bodies thereof, and the elastic beam assembly of each gyroscope comprises:

two common elastic connection beams, positioned at both sides of the proof masses;

a number of first elastic beams, connecting the proof masses and the driver bodies to the common elastic connection beams; and

a number of second elastic beams, connecting the common elastic connection beams to a central anchor fixed at the two plates.

28. The planar solid-state three-axis inertial measurement unit as claimed in Claim 26, wherein each elastic beam assembly further comprises a number of third and fourth elastic beams connecting the proof masses and the driver bodies to an outer frame fixed at the two plates.

29. The planar solid-state three-axis inertial measurement unit as claimed in Claim 27, wherein each elastic beam assembly further comprises a number of third and fourth elastic beams connecting the proof masses and the driver bodies to an outer frame fixed at the two plates.

30. The planar solid-state three-axis inertial measurement unit as claimed in Claim 25, wherein the configuration of each drivers assembly is constructed by the electrodes of the surface of each plate and the corresponding surface of each driver body; each surface of each driver body of the first, second, third and fourth gyroscopes respectively including a number of grooves or stripe holes respectively perpendicular to the y-axis, x'-axis, y-axis and x'-axis; the surface of each plate corresponding to each driver body being formed two sets of driving electrodes, respectively including a number of stripe electrodes parallel to the grooves or stripe holes of the driver body, the two sets of driving stripe electrodes being interposed each other and being formed two sets of driving capacitors with the corresponding surface of the driver body.

31. The planar solid-state three-axis inertial measurement unit as claimed in Claim 25, wherein the configurations of the first and second sensors assembly are respectively constructed by each surface of the first and second proof masses, and each surface of the third and fourth proof masses and the electrode of the surface of each plate corresponding to the proof mass.
32. The planar solid-state three-axis inertial measurement unit as claimed in Claim 25, wherein the configurations of the third and fourth sensors assembly are respectively constructed by each surface of the fifth and sixth proof masses and each surface of the seventh and eighth proof masses and the electrodes of the surface of each plate corresponding to each proof mass; each surface of the fifth and sixth proof masses including a number of grooves or stripe holes perpendicular to the  $x'$ -axis; each surface of the seventh and eighth proof masses including a number of grooves or stripe holes perpendicular to the  $y$ -axis; the surface of each plate corresponding to each proof mass being formed two sets of sensing electrodes, respectively including a number of stripe electrodes parallel to the grooves or stripe holes of the proof mass, the two sets of sensing stripe electrodes being interposed each other and being formed two sets of sensing capacitors with the corresponding surface of the proof mass.
33. The planar solid-state three-axis inertial measurement unit as claimed in Claim 25, wherein the coordinate system  $(x', y', z)$  is coincided with the coordinate system  $(x, y, z)$ .
34. The planar solid-state three-axis inertial measurement unit as claimed in Claim 25, wherein the coordinate system  $(x', y', z)$  is obtained by rotating the coordinate system  $(x, y, z)$  a specially designated angle about  $z$ -axis; the sensed  $x'$ -component and  $y'$ -component angular velocity and acceleration signals can be transferred to the  $x$ -component and  $y$ -component angular velocity and acceleration signals.
35. The planar solid-state three-axis inertial measurement unit as claimed in Claim 25, the main configuration thereof being manufactured with a (110) silicon chip by bulk micromachining technique.